

ESA-066 Public Report

Introduction:

The United States Department of Energy (U.S.DOE) Save Energy Now Program completed an Energy Saving Training-Assessment at Eastman Chemical Company's Tennessee Operations located in Kingsport, Tennessee. The onsite activities occurred May 8, 9, and 10, 2006. The principal investigator for the steam system assessment was Greg Harrell, Ph.D., P.E. from the Energy, Environment and Resources Center of The University of Tennessee Knoxville.

Eastman's Tennessee Operations is a large chemical facility manufacturing a large variety of products. Steam is distributed throughout the facility from 14 coal-fired boilers. Typically from 12 to 14 of the boilers are in operation. There are also three natural gas-fired boilers that serve as backup and support steam generators.

The coal-fired boilers are nominally rated to produce from 160,000 lbm/hr to 600,000 lbm/hr. The combined nominal steam production for the site is 3,500,000 lbm/hr.

Steam is produced at two pressures—high-pressure (1,500 psig, 950°F) and medium-pressure (600 psig, 750°F). Approximately 90% of the steam generated is produced at 1,500 psig; the remainder of the steam production is from the 600 psig boilers. Essentially all of the 1,500 psig steam passes through backpressure steam turbines.

The site is equipped with a wide array of steam turbines. The majority of the turbines are coupled with electric generators; however, some of the turbines drive auxiliary equipment; such as, boiler feedwater pumps and boiler fans. The nominal electrical generation of the turbines combine to equal 150 MW. Several of the turbines are extraction type turbines. Reduced pressure steam is discharged from turbines and distributed to the site at 100 psig and 15 psig. Some of the extraction turbines are extraction-condensing turbines.

The nominal total site electrical demand is 165 MW. Therefore, the site is typically a net importer of electrical power. In general, the impact electrical power is purchased based on an electrical cost structure that includes electrical energy consumption and peak electrical demand. The electrical costs are dependent on time of day.

Coal is the base fuel supplied to generate steam and power at the site. Coal supplies total approximately 45,800,000 10⁶Btu/yr fuel energy supply, which is approximately 90% of the fuel input energy to the site. The remainder of the fuel supply to the site is natural gas. Natural gas consumption for the site totals approximately 4,100,000 10⁶Btu/yr; however, it should be noted that the vast majority of this fuel is used for process heating purposes. Only 190,000 10⁶Btu/yr of natural gas is used to produce steam.

Objective of ESA:

The Energy Savings Assessment is designed to be an onsite *Training-Assessment*. The Training-Assessment places a system specific specialist onsite to evaluate the steam system, assess the operating performance of the steam system, and chart a course for operational and management improvement of the system. The primary strength of this activity is that site personnel are trained in the field evaluation techniques, modeling techniques, and implementation strategies associated with steam system management.

The U.S.DOE Steam System Evaluation Tools are used for the investigations and the site energy assessment team is trained in the use of the tools. These tools are software based and provide the site participants with powerful evaluation components to aid in system energy management. Furthermore, because replication is a primary focal point, it is a primary goal of the program to involve all interested personnel. Personnel from other sites are invited to participate in the Training-Assessment.

There are three primary goals of the Training-Assessment. The first goal is to identify realistic energy saving projects that will satisfy acceptable economic criteria for implementation. The target projects are fundamental in nature with low technical and financial risk. The second goal is to train site personnel in the evaluation techniques, management techniques, and practical applications of steam system management. This involves field measurement methodologies, U.S.DOE Steam Tools training, and general principles training. The third primary goal is to identify Best Practices that are in use at the site. This identification is designed to highlight excellent activities that are broadly applicable and can be replicated throughout the industry.

Focus of Assessment:

The complete site steam system served as the focal point for this Training-Assessment. The site is heavily involved in cogeneration activities; therefore, all of the investigations included system interactions.

Approach for ESA:

This Energy Savings Training-Assessment was executed with a non-traditional approach. The non-traditional approach was required primarily because of three factors. First, the site is very large, complex, and interconnected. As a result, the time allotted for the onsite activities was insufficient to allow a traditional investigation strategy. Second, the Core Assessment Team was primarily U.S.DOE Steam Qualified Specialists. Therefore, the training aspects were necessarily presented at an upper level. Third, the site energy team continually investigates potential opportunities. Because of this, there were minimal fundamental issues and opportunities. The projects investigated by the Training-Assessment Team were identified by the site Energy Team.

General Observations of Potential Opportunities:

The following subsections of this report briefly discuss the projects recommended for additional investigation or implementation. The projects presented here have an economically attractive implementation potential. In the project descriptions an indication of the implementation timing is provided. A qualifier is assigned to each project—*near-term*, *medium-term*, or *long-term*. These descriptors are identified as follows.

- ❑ *Near-term* opportunities would include actions that could be taken as improvements in operating practices, maintenance of equipment, relatively low cost actions, or equipment purchases.
- ❑ *Medium-term* opportunities would require purchase of additional equipment and/or changes in the system such as addition of recuperative air preheaters or the installation of a significant condensate collection system. It would be necessary to carry out further engineering and return on investment analysis.
- ❑ *Long-term* opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.

1 Boilers 18, 19, 20, 21, and 22 Combustion Set-point Adjustment

Coal-fired boilers 18, 19, 20, 21, and 22 are stoker-fired boilers producing 600 psig steam. These boilers are equipped with continuous-automatic combustion control. The typical flue gas oxygen content of these boilers is nominally 6.5%. This flue gas oxygen content is considered good for this type of boiler and fuel. These boilers typically operate with a combined steam production of 350,000 lbm/hr. The boilers are generally operating with loads greater than 50% of design steam production. It is recommended to execute a trial that will reduce the flue gas oxygen content of these boilers. The flue gas oxygen content controller should be adjusted to only reduce the oxygen set-point in the medium and upper ranges of the boiler load. The adjustments are expected to allow the boilers to operate with oxygen concentrations in the 5.5% nominal range. The savings opportunity is relatively minor and is identified as \$50,000/yr. The risk associated with implementing the change is considered minimal. Flue gas combustibles monitoring should accompany the reduction in oxygen content. The current combustibles concentrations are relatively low for coal fired boilers. This is considered a near-term project.

2 Building 423 Minimum-Fire Reduction

The three natural gas fired boilers operate in backup and standby conditions. Each of the boilers is nominally rated to produce 160,000 lbm/hr of 600 psig steam. In general, the operation of these boilers consists of one boiler operating at minimum-fire conditions—the other two boilers are not in service. The total operating period for the described situation is approximately 2,700 hours/year.

Economic benefit can be attained by reducing the minimum-fire capacity of the boilers. This will allow less steam to be produced by natural gas—the difference in steam production will be supplied by the coal fired boilers. The natural gas boilers are each equipped with one burner. Site engineering personnel are pursuing a simple and robust alternative burner system that will allow the minimum-fire steam production to be reduced from 20,000 lbm/hr to 10,000 lbm/hr. This will result in an economic benefit to the site of approximately \$340,000/yr. The project will not result in fuel energy savings but it will shift 31,000 10⁶Btu/yr of natural gas consumption to coal consumption. This is a natural gas reduction of 16% (steam generation portion) and a coal increase of 0.1%.

The project cost estimate is approximately \$300,000. This investment will provide the complete design, purchase and installation of the project. This is an economically attractive and fundamentally sound project. This is considered a medium-term project.

3 Coal Gasification Turbine-Motor Change

The coal gasification facility operates a backpressure turbine as the prime mover of a cooling tower pump. The steam turbine receives 600 psig steam and discharges 15 psig steam. The 15 psig steam system in the area is not equipped with sufficient demand and venting 15 psig steam results. The turbine produces approximately 550 kW of shaft power and discharges approximately 12,500 lbm/hr of steam. The vent steam flow is measured to be essentially equivalent to the typical steam flow of the turbine. The cooling tower is not equipped with sufficient electric motor operated pumps to allow the turbine to be taken out of service to eliminate the venting. Therefore, a project is recommended to install an electric motor drive on the turbine driven pump. The project investment is approximately \$100,000. The energy related impact is a site savings of \$300,000/yr.

The energy related impact is developed from an increase in electrical purchases of 540 kW and a decrease in coal consumption of 174,000 10⁶Btu/yr—this is a 0.4% decrease in coal consumption. This project is considered a medium-term project with an excellent economic attractiveness.

4 Boiler 23 and Boiler 24 Steam Generation Increase

Currently, boilers 23 and 24 produce steam with the lowest cost to the site. The primary reasons for this are the facts that these boilers produce 1,500 psig steam, they can burn the lowest cost coal provided to the site, and they operate with high efficiency. As a result, increasing the steam production from boilers 23 and 24 will allow the steam production from 600 psig steam generators to be reduced. The benefit is in the generation of electricity from the high-pressure steam. Relatively low-cost coal energy is converted into relatively high-cost electrical energy.

Boilers 23 and 24 operate in the upper regions of their acceptable steam generating capacity. However, the steam production rate appears to be below the maximum comfortable steaming rate. Increasing the steam production rate of the boilers by 1% will reduce operating costs for the site approximately \$50,000/yr. This is equivalent to increasing the steam production 5,000 lbm/hr on each boiler.

If this is accomplished, the power generation at the site will increase approximately 260 kW. Along with this, the coal consumption will increase slightly (5,300 10⁶Btu/yr). The implementation cost of this project is zero—it requires operating the boilers at an increased load. This project is considered a near-term activity.

5 Off-Peak Condensing Power Management

The impact cost of electricity varies with respect to time of use. In other words, the *on-peak* and *off-peak* electrical power costs are different—with off-peak costs lower than on-peak costs. The cost of generating steam and producing condensing power at this site is generally cost effective during on-peak periods. However, the economic incentive is eliminated during off-peak periods—this is especially true of the higher cost condensing power producers at the site. The off-peak period is equivalent to approximately 58% of the year. It is observed that condensing power generation can be reduced by more than 10 MW during the off-peak periods. An off-peak condensing power generation analysis indicates that if only 5 MW of this target condensing power is reduced during 40% of the year, the economic benefit to the site will be \$150,000/yr. This activity can be accomplished with no investment and is considered a near-term project. The electrical purchases of the site will increase 17,520,000 kWh/yr and the coal purchases will decrease 253,000 10⁶Btu/yr.

6 Building 326 Flash Steam Recovery

A large condensate stream, approximately 600,000 lbm/hr, is returned to the building 325 boilers with a temperature greater than the atmospheric pressure boiling point—approximately 225°F. This condensate stream is mixed with lower temperature condensate streams in a large atmospheric pressure vessel. The interaction of the streams is not sufficient to allow the elevated temperature condensate to mix with the low temperature condensate prior to flashing. As a result, a large amount of flash steam is discharged from the vessel.

Previously, a heat exchanger was in place to capture the energy in the condensate to avoid loss. The heat exchanger failed and was not replaced. The general piping arrangement remains in place. If a heat exchanger is installed to recover the condensate, energy fuel (coal) savings will result—108,600 10⁶Btu/yr. Recovering this energy will reduce the amount of backpressure power generation because less steam will be required for the deaerator. Therefore, electrical purchases will increase approximately 585 kW. The combined economic impact will be a benefit to the site of approximately \$100,000/yr. The heat exchanger required for this service is relatively large. A gross purchase and installation cost for the heat exchanger is \$200,000. Additional investigation is required to verify the potential of this project. Also, the additional site activities targeting reducing low-pressure vent steam must be successful to allow a true capture of energy in this situation. This project is considered a near-term project.

7 Insulation Repair

The thermal insulation throughout the site is observed to be in good condition. The piping is generally appropriately insulated with adequate jacketing. However, there are several pipes observed to have missing insulation. Site engineering personnel have completed extensive investigations of targeted areas of the site. The approach taken in investigating and eliminating insulation issues is excellent and is considered a Best Practice approach. Initial surveys have targeted the high-priority areas that include the process heating fluids (Dowtherm). Dowtherm is a relatively high-temperature heat transfer medium at this site and it is provided thermal energy from natural gas (a relatively high-cost energy source).

The Dowtherm systems have not been completely evaluated at this point, but the identified energy savings potential is approximately \$1,000,000/yr of natural gas expenditures—90,000 10⁶Btu/yr. This translates into approximately 2.2% of total natural gas energy input (process heating and steam). An insulation contractor has provided a re-insulation cost for the identified piping of \$300,000.

The steam system will be evaluated in detail in the near-term. Preliminary investigations indicate the energy loss from the steam system (resulting from damaged or missing insulation) is more than the Dowtherm system. The steam system is generally lower-temperature than the Dowtherm systems but the steam systems are far more expansive. Steam is distributed throughout all areas of the site. Steam piping is exposed to more outer covering hazards than the Dowtherm systems. As a result, a gross projection of steam system insulation loss is 400,000 10⁶Btu/yr. This is less than 1% of coal energy input, but it translates into approximately \$1,000,000/yr of potential savings. This is a high-priority focus area that is considered a medium-term project.

8 Condensate Recovery

The steam system serves a very large number of heat exchangers. One of the heat exchangers in the Acid-Con area is equipped with a condensate collection and recovery system. However, the condensate system is not functioning properly and the condensate is being discharged to the sewer. The condensate receiver serving the area operates with backpressure that is preventing the effective discharge of condensate from the heat exchanger in question. The condensate discharge rate is greater than 20 gallons/minute of saturated liquid near atmospheric pressure.

The installation of a pressure powered pump could eliminate the condensate loss. A pressure powered pump utilizes steam pressure (100 psig would most probably be required in this case) to pump the condensate into the collection system. The condensate savings is greater than \$14,000/yr. The pressure powered pump installation is expected to require an investment of \$25,000.

Recovering condensate will increase site power purchases (or increase condensing power generation) and reduce fuel (coal) consumption. Electrical power increases are estimated to be 68 kW and coal reductions are estimated to be $12,200 \times 10^6$ Btu/yr. This is considered a medium-term project.

Management Support and Comments:

All of the support provided for this activity was exceptional. The Training-Assessment was well planned and preparations were excellent. It is notable that the site has several U.S.DOE Steam Qualified Specialists and focuses significantly on energy. These participants have accomplished substantial improvement in the management of the steam system.

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